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SPRINKLING FOR IRRIGATION

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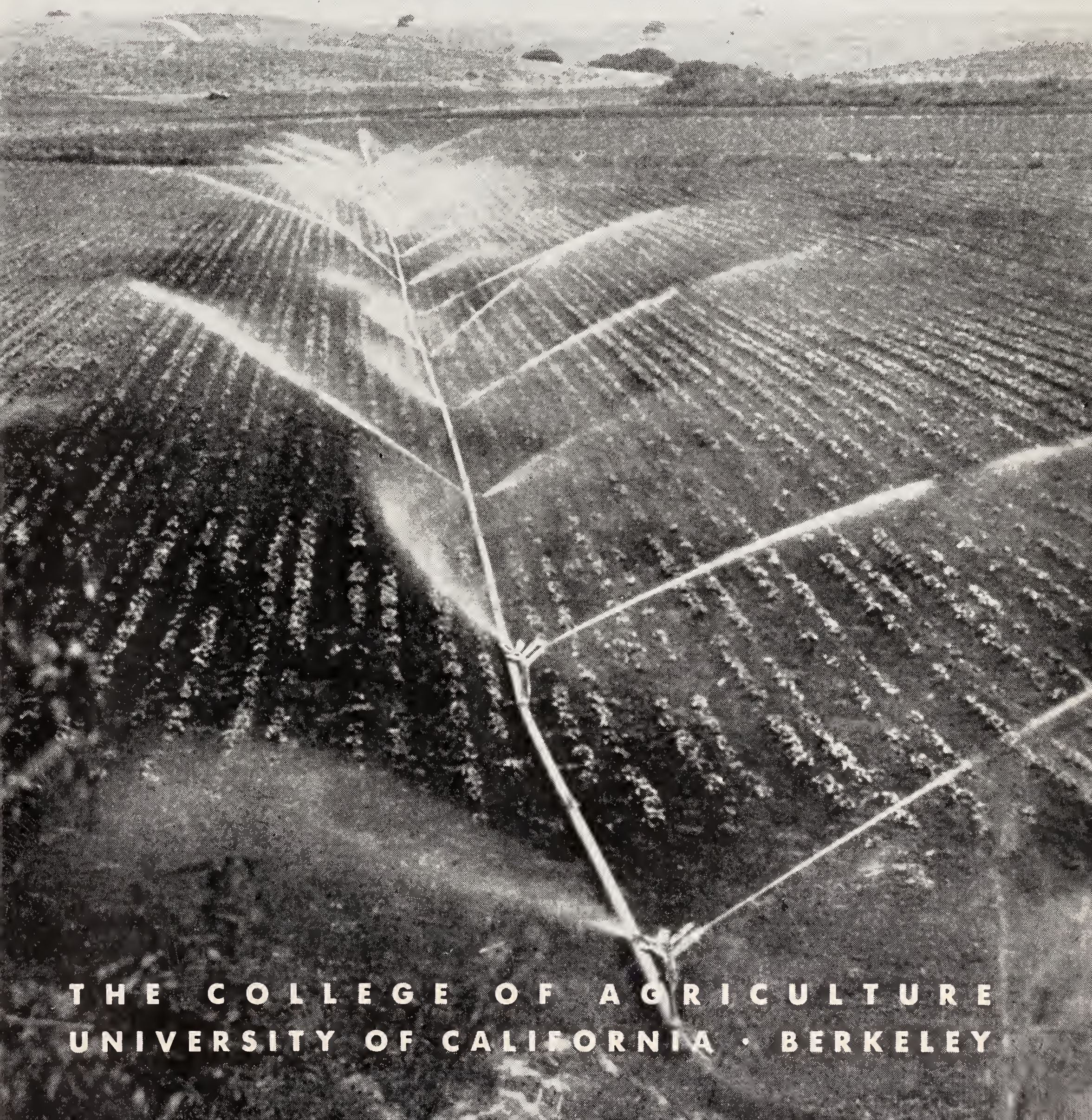

THE COLLEGE OF AGRICULTURE
UNIVERSITY OF CALIFORNIA · BERKELEY

● CALIFORNIA FARMERS are always on the lookout for ways to improve their IRRIGATION practices.

● Many in the last fifty years have tried SPRINKLING OF CROPS. Some have used sprinkling on all or part of their farms to replace the usual furrow irrigation or flooding; others have used it to supplement those methods at certain times.

● SPRINKLING IS EXPENSIVE. Partly because of this, and partly because of broad claims sometimes made for sprinklers, it is easy for the farmer to expect too much of sprinkler equipment. In his case the results might equal the claims, or they might not. Wisely, he wants to find out in advance.

● SPRINKLING assuredly HAS A PLACE in California Agriculture, BUT IT IS NOT A CURE-ALL. Where used, it must be adapted to the conditions. The individual farmer will wish to satisfy himself beforehand on FOUR MAIN POINTS.

One . . . .

Does my farm have the kind of topography, soil, subsurface conditions, climate, and crops to make the use of sprinklers advisable?

Two . . . .

What kind of sprinkler system do the conditions on my place call for, and how large must the system be?

Three . . . .

What would such a system cost to install, maintain, and operate?

Four . . . .

Would the advantages justify the increased cost over cheaper means of irrigation?

THIS CIRCULAR does not pretend to give the answers to these questions for every farmer. But it conveys information he will need in approaching a decision.

Sprinkler systems are all alike in some ways

SPRINKLER SYSTEMS all carry water under pressure through pipes to devices that toss it up on the soil. The devices may be sprinklers, nozzles or spaced perforations in pipe. The pressure may be provided by gravity from a source at a higher level, or by pumping. In other methods of irrigation the final distributing of water is done by the soil; in sprinkling, by mechanical means.

Sprinkling is only another method of applying water. Only after making cost comparisons with other methods and taking all other factors into account can the farmer be sure that a sprinkler system will be a good investment.

Their job is to get water to the plants

Sprinklers, like other irrigation systems, must apply water to the soil in such quantities, at such a rate, and at such times, that the plants can get enough for their needs.

During rain or any irrigation, water fills the pore spaces between the soil particles. But saturation soon ends; some of the water drains down, or sidewise, from the wetted area. What the soil is able to hold onto after the drainage—about 2 or 3 days after the wetting—is called its **field capacity**.

Some of this remaining water eludes the plants by evaporating. The roots go after what is left. As long as the major part of the root system can reach **readily available moisture**, the plants function normally.

However, a certain amount of the water is not readily available. It is held so tightly by the soil particles that the roots cannot absorb it fast enough for the plants' needs. When the plants have to depend upon this source, the soil-moisture content is said to have dropped down to the **permanent wilting percentage**. Some plants show this by a wilting of the leaves in the late afternoon and next morning. Others show it by slower growth of plant and fruit or by a change in color of leaves. Some eventually die. In any case the normal functions are limited—unless more water is applied.

Soils differ greatly in ability to take and hold water. Sandy soils and gravels take water faster than the finer-textured clay loams and clay soils, but retain less after drainage because they have fewer particles and therefore fewer water-holding wedges. The amount of water held by a soil at field capacity varies from about 1 inch per foot of depth for sandy loam to 4 inches for some clays. A shallow soil will hold more water per foot of soil at the field capacity than a deep soil of the same kind. Shallow water tables increase the water held in the soil occupied by the roots. Lack of uniformity in successive soil layers also affects field capacity.

Generally, a soil with a high field capacity will hold large amounts of readily available moisture. But not always: some sandy soils do better in this respect than some clays. Some soils make only one fourth of their field capacity readily available to plants; others freely give up to three fourths.

A soil at field capacity is something like a full rain barrel with a faucet in its side. The water above the faucet can be drawn off; it is the readily available moisture. If the faucet were lower on the barrel's side, more of the water could be taken. Some soils are like barrels with high faucets; others like those with low faucets. They present different problems in irrigation—often on the same farm.

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Sprinklers are of many types

Although having certain things in common, sprinkler systems differ widely. They are classified as "portable" when most of the mechanical equipment can be moved readily from place to place over the area irrigated; "semiportable" when only a minor part of the equipment is moved; "stationary" or "permanent" when all the equipment is fixed.

Systems may be classified also according to method of distributing the water. This may be by means of rotating sprinklers, fixed sprinkler heads, nozzle lines, or perforated pipe line.

In California portable systems using rotating sprinklers outnumber all other crop sprinkling systems combined.

Sprinkling is often called "overhead" irrigation. This is confusing, because the water does not always issue from an overhead outlet. One true "overhead" system is the kind that throws water over orchard treetops from outlets attached to high risers; but even in orchards some sprinklers (called "under-tree," "low-head," or "ground types") distribute the water near the ground.

Different Kinds of Outlets Do Different Kinds of Work . . .

Rotating Sprinklers Where sprinkler systems must cover large areas, rotating heads usually are employed. These have capacities of 1 to more than 400 gallons per minute. Some of the larger ones are designed for pressures of 60 to 100 pounds per square inch, and will cover circles up to about 375 feet in diameter. Some of the smaller ones will operate at 10 pounds or less.

For supplemental irrigation, where the annual water requirement is low, high pressures and large sprinklers may be more economical than small sprinklers because of the greater permissible spacing of pipe lines. (For some rotating sprinkler heads, see figure 1.)

Rotating sprinklers are of two types: **slow-revolving,** that rotate slowly, and **whirling,** that rotate rapidly. Slow-revolving sprinklers ordinarily make one or two revolutions a minute; some are much slower still. Various types of driving mechanisms are used to produce the slow rotations; some have uneven action, and this variation may affect the distribution of water.

The slower a sprinkler operates, the larger area it will cover. When operating under pressures of about 40 pounds per square inch, slow-revolving sprinklers will cover areas up to 165 feet in diameter. Whirling sprinklers of similar capacities, under equal pressure, will cover areas 50 to 75 feet in diameter.

Whirling sprinklers generally cost less and tend to rotate at a more constant rate because of the momentum of the revolving parts. But the slow-revolving sprinklers have a number of advantages that make them the most popular type in California agriculture: (1) Covering a greater area, the slow-revolvers permit the economy of greater spacing of pipe lines. (2) They apply less water per hour to a unit of land, a very desirable feature where the soils are not highly porous. (3) Slow rotation cuts wear, prolonging the life of the sprinkler.

Fixed Heads Fixed heads (see figure 2) are used mainly for lawns and for some portable under-tree systems for orchards. These heads have no moving parts. They are designed to operate at pressures of 10 to 25 pounds per square inch and to deliver water at the rate of 1½ to 5 gallons, or more, per minute. They cover areas 15 to 25 feet in diameter with a fine spray fairly evenly distributed.

Translated into depth, their normal rate of delivery is 0.7 to 3 inches per hour. This rate is too high for some soils to absorb without run-off or puddling.

For portable under-tree orchard sys-

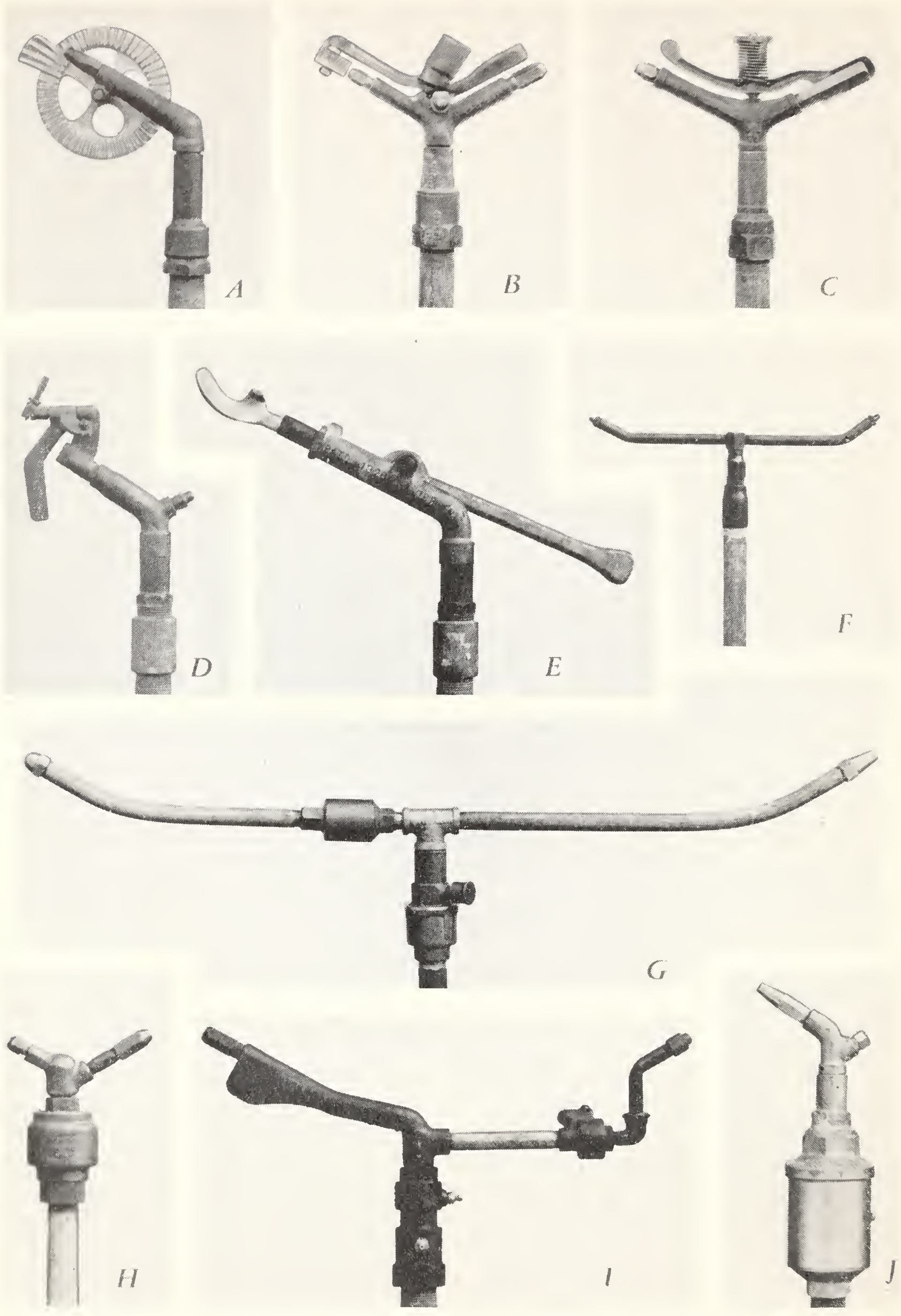


Fig. 1. Some types of rotating sprinklers. *A, B, C, D,* and *E,* sprinklers with external driving mechanisms: *A*, spinning-wheel type; *B* and *C*, oscillating spring type; *D* and *E*, pendulum type. *F*, reaction-drive whirling sprinkler. *G* and *I*, reaction drive with vibrator for slow rotation. *H* and *J*, internal-drive sprinklers: *H*, friction type; and *J*, gear type.

tems on permeable soils the fixed heads are highly desirable because their cost per unit is low. For other orchard and field uses, their use is limited. For stationary systems, the cost is excessive, because of the close spacing required; further, the closely spaced heads interfere with cultivation.

Nozzle Lines Nozzle lines (see figure 3) are always more or less stationary. They are relatively expensive, and so they are generally used only for crops yielding a high gross return, such as certain truck crops and small fruits, and for nurseries, greenhouses, lawns, and other special purposes. They are used occasionally in orchards, especially on terraced plantings.

The nozzle lines are, as a rule, parallel lines of pipe, ¾ to 1½ inches in size, each fitted with a row of small brass nozzles spaced 2 to 4 feet apart. For field work the pipe ordinarily is supported on posts set about 15 feet apart. Four feet above ground is a common height, but 7 feet may be used where passage underneath is required for cultivation. Sometimes the pipe is held up by a suspension cable from much higher poles set 100 to 200 feet apart.

To wet a strip on both sides, the pipes are slowly rotated through an angle of about 90 degrees (from about 45 degrees on one side to the same on the other). This can be done by means of a special hand-turning union, but is generally done by a water-operated oscillating motor. The oscillators are, usually, double-acting piston devices. Being fairly expensive, they are made to do multiple duty. Sometimes they are moved from line to line; in other cases they operate several parallel lines at one time by means of cables attached to arms on each line.

Nozzle lines generally operate at pressures of 25 to 40 pounds per square inch. At 30 pounds the nozzles in common use can deliver 0.15 to 0.30 gallons per minute. Where the pressure is adequate, the lines are spaced about 50 feet apart.

The nozzles, being small, clog easily. Water containing algae or other clogging matter must be screened, and this is done usually at the head of the line.

Perforated Pipe Lightweight portable pipe with holes so spaced in its sides as to expel water at various angles has come into use for low-growing crops. It is laid on the ground; so plants too high and close will impede its operation. (See figure 4.)

This pipe is available in two types, one applying about 1 inch of water per hour and the other about 2 inches. It distributes the water fairly uniformly in a strip along the line. This strip varies with the pressure, from about 50 feet at a pressure of 20 pounds per square inch to about 20 feet at pressures as low as 4 or 5 pounds. In many cases the low pressures required can be supplied by gravity.

The relatively high rates of application

Fig. 2. Some types of fixed sprinkler heads.

Fig. 3. Stationary nozzle line used for irrigating strawberries. Oscillating motor at head of the line slowly rotates this pipe back and forth so as to wet a strip on each side of it. Nearest jets are different from others; they come from six special nozzles being tested.

necessitate frequent moves of the pipe, and make these sprinklers most suitable on pervious soils. Since it is not possible to regulate and equalize the pressure along the line as with sprinkler heads, it is essential to lay the pipe along the contour rather than up and down a hillside. It is important to remember this when perforated pipe is used.

Stationary, Semiportable, and Portable Systems . . .

Stationary Systems Stationary types were once the most popular sprinkler systems in California farming. Most of the original orchard systems were of that type, with rotating sprinklers mounted on high risers over the trees. (See figure

Fig. 4. Portable perforated line irrigating young alfalfa. The system operates at low pressure.

5.) Today, however, except for nozzle lines, few stationary systems are being put in.

It is true that once a stationary system has been properly installed, with fixed or rotary heads to fit conditions, the system has certain advantages over a portable system. It can duplicate a known performance over and over. It takes less attention and costs less to operate than a portable system, which must be shifted about from place to place.

However, its pipe lines, which supply water to the risers, interfere with cultivation unless buried fairly deep; and the risers and their attached sprinklers may interfere also unless extra precautions have been taken in planning. More important still, the present cost of installing stationary systems generally is prohibitive.

Semiportable Systems Some sprinkler systems have stationary pipe lines and portable sprinklers. They are especially adaptable for orchards. They are less expensive than stationary systems and they obviate certain practical difficulties of portable systems.

Frequently, in semiportable systems, the portable sprinklers are of the undertree variety. Sometimes, however, true overhead systems are involved. In the latter cases, the high risers are usually made in two sections with a shut-off valve between. The lower part, with the valve, is permanently attached to the stationary pipe, which lies on the ground or underground. The upper part of the riser, with the sprinkler, is removed from the lower section after use, carried to the next position and there fitted to another lower section. The operation is much easier than moving wholly portable high risers through an orchard and fixing them in a vertical position each time.

Fig. 5. Stationary system, with fixed high risers, sprinkling an orchard.

In a semiportable system, 6 or 8 portable sprinklers may do for a 10-acre tract, whereas a stationary system would require more than 100. A further saving is possible in the cost of pipe lines, because smaller sizes may be used in a semiportable system when each sprinkler is operated on a different lateral.

Portable Systems There are two types of layouts generally known as "portable systems." In one, the water is pumped

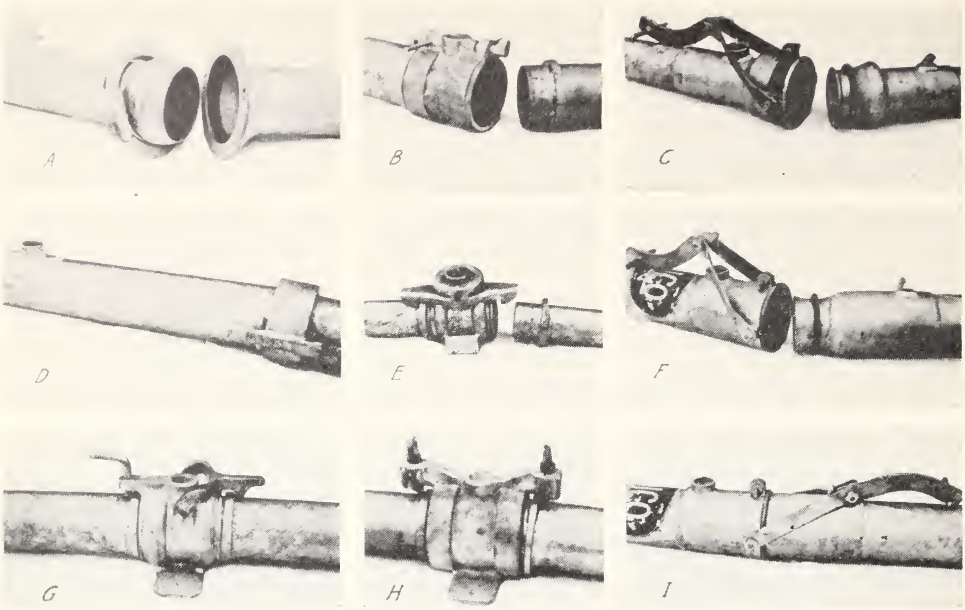


Fig. 6. Some types of portable sprinkler-pipe couplings, with sprinkler outlets in or near the couplings. *A*, Shur-Rane, ball and socket type; *B*, Montague; *C*, Calco (3-inch); *D*, Rain Storm; *E*, Pierce; *F*, Calco (4-inch); *G*, Wilson; *H*, Shur-Rane; *I*, Calco (4-inch, coupled).

from an **open ditch or concrete pipe line,** and the portable system consists of the pumping plant plus a sprinkler line of special lightweight portable pipe to which the sprinklers are attached. In the other, the water is usually pumped from a **well,** and the system consists of a main distribution line which may be portable or permanent, and one or more laterals or sprinkler lines of lightweight portable pipe to which the sprinklers are attached.

The portable systems are used largely for irrigating field and truck crops, such as sugar beets, peas, beans and onions. The pipes have quick couplings. The sprinklers commonly used are of the slow-revolving type.

Portable sprinkler pipe comes in standard lengths of 20 feet; other lengths are furnished on special order. Sprinklers generally are spaced 20, 40 or 60 feet apart. The pipe is moved across the field by carrying, with one or two men to each length.

Several makes of pipe are available, each with a different kind of coupling. (See figure 6.) Most systems require little or no turning of the pipe in making the coupling. Each pipe section contains a rubber gasket at one end. The water pressure holds the gasket tightly in place to prevent leakage as the flow continues from one pipe into the next. The arrangement allows for rather loose coupling, and for consequent flexibility of the line so that it can follow the rough surface of the land.

In some systems the outlets that serve the sprinklers are in the couplings; in others, the outlets are welded to the pipe near the couplings.

Types of Pumps There are two types of portable pumping plants: the tractor type that utilizes its own power both to operate the pump and move from one location to another; and the independent engine type, where a separate engine is used for operating the pump. The latter may consist of a truck, a trailer, or skids on which the pump and engine are mounted. The tractor type is most com-

mon, probably because in many instances a tractor required for other farm work is available during the irrigation season.

Special lightweight centrifugal pumps have been designed for use on portable systems. They are usually mounted on the front or rear end of the tractor.

Stationary pumping plants often require booster pumps. Where water is pumped from a well with a deep-well turbine pump, however, the increased pressure required for sprinkling can be provided, instead, by additional stages (bowls) on the pump. In this case a larger power unit will be needed and other details of pump construction must be considered.

Frequently the stationary pumping plants are electric-driven instead of the internal-combustion type. If so, their operating cost may be somewhat higher and their speed cannot be so easily adapted to the changing needs of the sprinkler system; but they require less attention.

Use of Ditches Where water is pumped from a ditch at the side of the field the line of portable pipe extends across the field. (See figure 8.) This arrangement is practical for a pipe line not over 1,000 feet long. After the desired application, usually 2 to 6 hours, the pump is shut down and moved; men take the pipe apart, carry it to the next (parallel) position, couple it, attach the sprinklers and connect pipe with pump. Now the system is ready for another run.

Where the ditch runs down the center of the field, the pipe runs across the field on both sides of the pump. (See figures 7 and 9.) This "split line" arrangement is far more efficient. It permits use of smaller pipe and allows for nearly continuous operation of the pump. The pipe line on one side of the pump is shut down while the line on the other side continues to operate. The pump is then shut down, moved to the next position, connected to the line that has been moved, and started up. The other line is then moved, connected to the pump, and turned on.

If the pump's capacity is not adequate for operating the lines on both sides at one time, the water is not turned into the last-moved line until time to shut down and move the other.

Use of Main Pressure Lines Where a main line is to supply the water, it is best laid down the middle of the field;

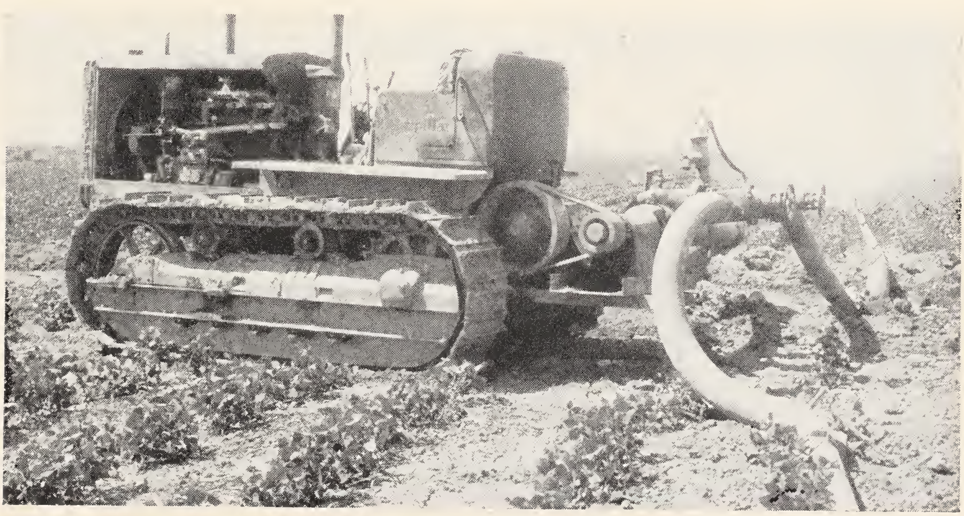


Fig. 7. Portable pumping plant, mounted on tractor, alongside open ditch inside field. It is drawing water from ditch through large hose (visible directly below priming pump). It is forcing water into two portable lines serving 61 sprinklers.

and where a stationary pumping plant at a well in the field is to supply the pressure, it had best be located in the center of the field if feasible.

An ideal portable arrangement with stationary pumping system is shown in figure 10. With the pumping plant at the center, minimum pipe sizes can be used and friction losses held lower than when pumps are located at the boundaries of the field. The water is supplied to the portable lines from hydrants located along the pressure line. Any number of portable laterals can be used on the pressure supply line. With two or more laterals the pumping plant can be operated continuously.

This arrangement, the most satisfactory from the standpoint of operation, costs somewhat more than systems using portable plants. That is because a stationary main pressure supply line represents an investment usually greater than the cost of the portable pipe. Reinforced concrete pipe is being used by some farmers to avoid the higher cost of iron or steel. Plain concrete pipe as ordinarily used for irrigation systems is not strong enough to withstand the pressures needed by most sprinkler systems, therefore, ordinary concrete pipe cannot be recommended.

Drag-Type System A drag-type portable system is sometimes used in orchards. Here a portable pipe line is moved from position to position by being dragged endwise. The work is done either by hand—if the unit is small—or by one horse, a team, or a tractor. The idea is to cut the labor cost of moving portable pipe. Also, when one or two lengths of pipe are used ahead of the first sprinkler on the line, it is not necessary to work on wet ground to move the pipe.

For hand-pulling, the drag lines should be light. Even ¾-inch, type-M copper tubing has been used for the purpose. For heavier units, drawn by tractor, a wheel cart may be used at the head of the line to hold the risers vertical while they are being moved. Aluminum pipe will not stand abrasion and should not be used with a drag-line system.

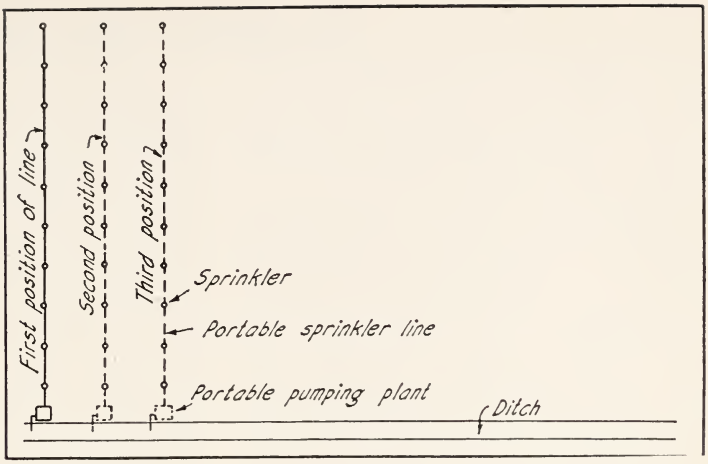
Traveling Sprinkler Machines Some growers use traveling sprinkler machines that pump water from a ditch and distribute it through large sprinkler nozzles which they carry. These machines move continuously along the ditch; most of them are on tractors geared down to move 1 to 5 feet per minute.

At pressures of 60 to 80 pounds per square inch, they deliver 400 to 800 gallons per minute. Some cover effectively a strip 250 feet wide.

These machines are designed to cut labor costs by eliminating pipe to be moved. One man can operate them. The cost of constructing them is generally less than the cost of an ordinary portable sprinkler system of similar capacity. The cost of power for pumping is normally higher than for other systems because of the higher pressures required.

The machines require the construction of ditches spaced about 250 feet apart, and so their use is limited to relatively flat areas where such ditches are feasible. These ditches remove about 5 per cent of the area from cultivation. The operating cost should include the crop value of the area lost and also the cost of constructing the ditches.

Fig. 8. Single-line arrangement of a portable sprinkler system supplied from a ditch along one side of the field.



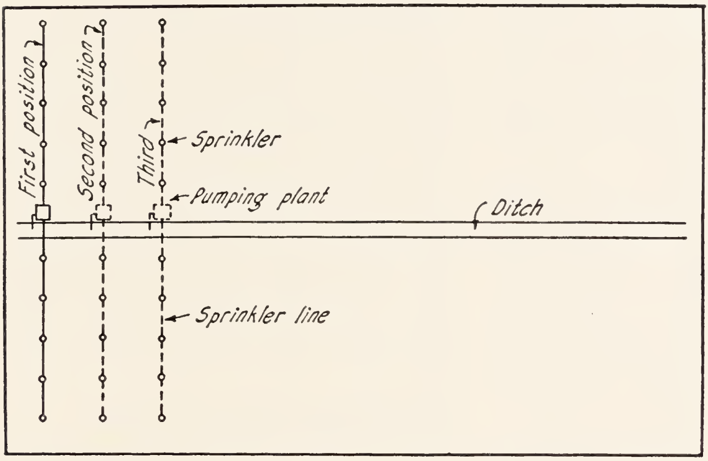
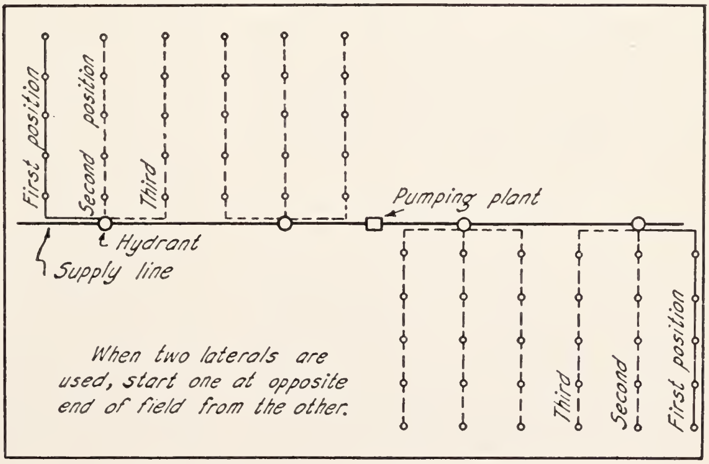


Fig. 9. Split-line arrangement of portable sprinkler system supplied from ditch running through middle of the field. This is more economical than the single-line arrangement shown in figure 8.

Fig. 10. Arrangement of a portable system operating from a main pressure line with a stationary pumping plant supplied from a well.



Sprinklers have advantages . . .

Sprinkling has some definite advantages. While claims made for it are sometimes exaggerated, it is successful under certain specific conditions.

Sprinkler systems can be designed to use effectively a smaller flow of irrigation water than is desirable for most other methods—an advantage to the operator of a small farm or orchard.

On land with rough or irregular surface features, sprinkling can eliminate the grading and leveling that would be required for surface irrigation. A sprinkling system might cost less than such land preparation, although this would not always be the case. The advantage of a sprinkler system might be pronounced on shallow soils, especially those underlaid with hardpan, for here the removal of a few inches of surface soil by grading could be very detrimental.

Where fields are not properly graded, or where the irrigation system is not carefully laid out, uniform distribution of water by surface methods is hard to obtain. Greater uniformity can be achieved by sprinklers. This is especially true where permanently rooted crops have been planted.

With sprinklers it is easier to adjust to the water needs of different soils in the same field. In some areas, especially on pervious soils with sand or gravelly subsoils, a large part of the water applied by surface systems may be lost by deep percolation unless such systems are well designed and are operated to avoid such losses. The same soils can be sprinkled without excessive waste.

For Seed Germination

Sprinkling can sometimes be considered as crop insurance. During spring months when drying winds are common, crops are frequently lost, or poor stands are caused by poor germination due to lack of water. Frequent light applications at this time may have beneficial results.

In some parts of California sprinkling is used primarily as a protection against erosion. Where orchards have been planted in straight rows up and down hillsides, furrow irrigation is often the only practicable method of surface irrigation. The result, frequently, has been excessive erosion. Sprinkling, combined with permanent cover crops, may prevent further loss of soil.

Sprinkler systems can eliminate many field ditches, and so permit the planting of almost the entire acreage. When they have this effect, the getting rid of ditches may in turn lessen the weed problem. It also allows cultivation in larger blocks.

Where the annual water requirement is low, sprinkling may be an economical method of irrigation. With portable systems the cost is primarily that of operation; and where little water is required over the year, sprinkling may cost less per acre than other methods of irrigation involving waste due to deep percolation. Some crops need only a single light application, which might be made more cheaply by sprinkling than by surface methods.

With High Water Tables

In the San Joaquin and Sacramento Delta, and along the Sacramento River, sprinkling is widely practiced where the water table lies within 2 to 4 feet of the surface. Here only light applications are needed. The sprinkling, incidentally, helps prevent the accumulation of salts in the surface soil. (On the other hand, the growth of weeds becomes a greater problem.)

Sprinkling is adapted also to conditions where a shallow soil is underlaid by either hardpan or gravel. With hardpan, because of the lighter applications and more uniform distribution of the water, temporary waterlogging can be avoided; and with gravel, excessive water loss and leaching may be prevented.

Sprinkling is a desirable method of irrigation in certain coastal areas where moderate temperatures and high relative humidity keep the seasonal water requirement low. In many such areas, rolling and sloping ground makes surface irrigation somewhat difficult and costly.

Sometimes portable sprinkler systems have been used to apply fertilizers in solution and then to wash the solution from the foliage to prevent burning. The practice is not widespread in California, however, and caution is the rule. Some of the fertilizer materials used, and especially ammonium sulfate, corrode metals. Also, clogging may change a system's performance.

. . . and also limitations

Sprinkling systems can be designed to distribute water fairly uniformly. But, contrary to some claims, they do not give the uniformity of rain.

They do their best work at prescribed pressures, for which they are designed. Below those pressures their performance falls off.

Usually, in sprinkler operation, a fine spray falls near the outlet, and larger drops fall toward the rim of the circle. Usually, too, less water is delivered to a unit of area near the outer edge. Any wind will disturb the pattern of distribution; a strong wind may keep part of the area unwetted.

To assure as much uniformity as possible, the sprinklers are so located, in squares or triangles, as to cause sizable overlaps of distribution.

One claim often made for sprinkling is that it requires less water than either flooding or furrow irrigation. This is not necessarily the case. While sprinkling can save water by preventing deep percolation, so can well-designed and well-operated surface-application systems.

With sprinkling, more water will be lost by evaporation than with other methods. This is true because during each sprinkling some of the spray itself evaporates, and also because the wetting of foliage as well as all of the soil exposes more surface water to evaporation.

The Factor of Cost

It is probable that sprinkling can be made to do a satisfactory job almost anywhere; but it is not always advisable. And it generally costs more.

When fields are properly prepared for surface irrigation, and where one irrigator can manage fairly large streams, the cost of application by surface methods will usually be less than that required by a sprinkler system. For a stationary sprinkling system the initial outlay is very high. For a portable system it is lower, but the labor charge is much higher because pipe needs to be shifted at intervals.

Speed of Application

Another factor that limits the usefulness of sprinkler systems, besides their cost, is the slow rate at which some soils will absorb water. The sprinkler system often delivers water faster than the soil will take it, and if the sprinklers are set at too low pressures they will throw out large drops that make things worse by tending to seal the surface.

From 3 to 8 inches of water is usually required to wet dry soils to the depth from which moisture is extracted by most crops; and under differing soil and crop conditions, 1 to 6 inches or more might well be applied at each irrigation. However, some soils take water so slowly that adequate applications by sprinkling are not feasible; only light applications can be made before the water puddles or runs off as waste.

The situation might be met by applying water more slowly and over a much longer period—12 hours, or even more. On some farms this is done. In many cases, however, it would mean unduly increasing the size of a portable system in order to cover the tract.

On some soils pipe cannot be moved

immediately after a heavy application, because the ground becomes too soft for workmen to do it. If the pipe could be left until the ground drained, before being moved for another run, that would not be a great drawback; but usually this would mean having alternate pipe for use elsewhere, at a heavily increased investment in equipment.

On soils of these types, then, the sprinklers usually are shut off and the lines moved before they have run long enough to wet the soil deeply. As a result, frequent light applications are necessary. But often-repeated sprinklers mean much moving of pipe, and hence added expense. Also, they mean a large increase in the percentage of water lost by evaporation, and that too costs money.

Where sprinklers are used on highly pervious soil, such as sandy and gravelly types, there is little danger that they will apply water too fast. The danger here is that the water will be applied too long, and, as in the case of poorly planned surface systems, that some will be lost by deep percolation.

Effect on Insect Control

In the realm of insect control, sprinkling has only limited value. It apparently aids in controlling thrips and red spider on beans and probably other crops, and it may reduce the number of aphids on peas. Where spraying or dusting is required, however, sprinkling may do harm because it tends to wash the residue from the plants. In tests in the state of Washington, years ago, each sprinkling was found to have removed an average of 29 per cent of arsenate of lead previously sprayed on apples for the control of codling moth. Apparently, too, sprinkling was detrimental in connection with most apple diseases, such as perennial canker fruit rot, pear blight, and downy mildew.

Some things to consider

The farmer, in considering a sprinkler system, must weigh all possible advantages and limitations, as well as the cost of a system suited to his particular needs. He will ask himself the four questions listed on page 3 of this circular. Before proceeding far, he probably will consult the experience of other farmers in his vicinity. What do they advise? He may also look to his county farm advisor for information.

It is important that the farmer understand the water needs of every crop and every soil on his farm. If he decides that a sprinkler system would irrigate certain fields more efficiently than his present method, or that at certain times of the year it could usefully supplement his present method, he should think in terms of a system that will be adequate.

A sprinkler system, to be adequate, must be able to apply water at the rate desired, for as long and as often as the crops require. Of course, it will take more water at one time to supply the roots of a walnut tree, which are active to a depth of 12 feet or more, than those of potatoes, which draw most of their moisture from the first foot of soil. And the quantity required will vary also with the amount of readily available water the soil can hold.

To put one inch of water on one acre takes a flow equal to 450 gallons a minute for one hour. From this, one can figure the capacity needed by a sprinkler system that has to put a given depth of water on a given area in a given time.

Choosing Among Systems

For certain purposes a stationary system may be preferred. The initial cost, however, may be so high as to dictate a portable, or possibly semiportable, system. Any system should be designed to meet the farmer's own needs. Sometimes, with very little additional outlay in equipment, the efficiency of a portable system can be doubled.

In general, the lowest initial cost results when a system is planned for continuous operation that will just satisfy crop requirements—including requirements during the critical part of the year. But whether a small system, operated more or less continuously, will be more economical than a larger system, operated only a few days for each irrigation, depends primarily upon the method of operation. If a small system requires continuous attention, it may not be economical because the labor cost of operating it may be very high. Where continuous attention is not necessary, and especially where the attention required can be given at convenient times, a small system operating continuously will also be the most economical to operate.

Sometimes it is possible, with a small portable system operated by the owner, to move the lines only once a day or twice (morning and evening) and to leave the system to its work while the farmer attends to other operations. This requires a system that is free from troubles; sprinklers sometimes clog or stop rotating, or the pump may lose its prime. Usually it is more feasible when pressure supply lines and stationary electric-driven pumping plants are used. At present this method is being practiced to a much greater extent with orchard systems than with other types.

For large field-crop portable systems with portable pumping plants, one may find it difficult to arrange the layout for slow rates of application that will permit 12-hour or even 8-hour periods of operation. Many such systems employ full-time crews day and night, moving the equipment every four hours.

Details of Equipment

Once the farmer knows roughly the kind, layout and capacity of the system he would need, he will be ready to consider details of equipment. He may know some one who can tell him what he needs in the way of pumps, pipes of various sizes, valves and sprinklers; to what extent friction in pipes and other equipment will reduce performance; how rust in some pipes will reduce diameter and cut results over the years; how to insure the proper pressure for the sprinkler system; the probable rate at which pipes and sprinklers will have to be replaced.

Much technical information bearing upon these problems is contained in Bulletin 670 of the Agricultural Experiment Station, a 124-page booklet on sprinkler systems. Moreover, sprinkler companies offer engineering service and, given the necessary information, will plan an economical layout and submit cost figures.

Figuring Annual Cost

After learning the initial cost—the investment in equipment and installation—the farmer will wish to estimate the total annual cost of sprinkling. This includes taxes, insurance, interest on investment, depreciation, and operating costs. To determine depreciation, he should figure the useful life and consequent annual depreciation rate for each item of the system separately. Utilities in the area may help him estimate how long underground pipe would last in his soil; other users, or manufacturers or dealers, may be able to estimate the useful life of other parts of the equipment.

The major cost to be figured is that of annual operation. It can be divided into two chief items: the power cost, including the fuel (or current), lubricating oil and other materials required for the pumping plant; and the labor cost, for handling the system.

One Farmer's Figures

Some idea of costs may be obtained from one actual design of a portable system. The farmer in this case had a field of 38.8 acres, almost square, over which he wanted to sprinkle 3 inches of water nine different times during the growing season. He wished to cover the field once in each 15-day period.

Knowing his soil's ability to absorb and hold moisture, he figured on setting his sprinkler lines in a different location twice every 24 hours, taking one hour for each move and 11 hours for each application. In this way he figured to cover his field in 12 days of the 15-day period.

He figured his system must have a capacity of 198 gallons per minute. He planned to lay a 5-inch iron main down the middle of the field and operate two portable aluminum laterals from it, one on each side, moving them 60 feet each time. Each lateral would have ten rotating sprinklers, spaced uniformly, which would give him the proper distribution if worked at a pressure of 40 pounds to the square inch.

The farmer would pump water into the system from a canal alongside the field, using a stationary pumping plant with electric motor. Allowing for the lift from the canal level to the highest ground level, and also for normal pressure loss from friction in the pipe system, he decided the motor must be of 10 horsepower.

Now he did more inquiring, some pricing, some arithmetic. He came up with these estimates of principal cost items:

INITIAL COST

Cost of pumping plant (with motor, starting equipment and other facilities)	$ 825.00
Cost of main line	1,822.50
Cost of laterals, sprinklers, reducers, ells, etc.	665.50
	$3,313.00
Add 10% for hauling and installation	331.30
Total installed cost	$3,644.30

ANNUAL COST

Fixed charges:		
Interest: 6% on $1,822.15 (half of $3,644.30 being taken as average investment under amortization)	$109.33	
Taxes and insurance: 2% on $1,822.15	36.44	
Depreciation (figured on average life expectancy of ten years for system)	364.43	
Total		$510.20
Operation:		
Power (electric energy, $260.64, and repairs and maintenance, $10.00	$ 270.64	
Labor (figured as one man's part-time labor for 1,296 hours at the conservative estimate of 85 cents an hour)	1,101.60	
Total		$1,372.24
Total annual cost		$1,882.44

From the foregoing, the farmer was able to see that a system of the kind he planned would cost him $93.93 per acre to install. Annually, the total cost per acre would be $48.52, consisting of $13.15 per acre for fixed charges and $35.37 per acre for power and labor.

Dividing the total annual cost by 1,047.6 (number of acre-inches of water to be applied in the year), he found that under his plan he must spend an average of $1.80 for sprinkling one inch of water over one acre.

Before proceeding with the plan he decided to investigate further. Perhaps he could find some other sprinkling method, or some surface-application method, that would serve his particular purposes at less cost.

Sprinkling is only another method of applying water. Only after making cost comparisons with other methods and taking all other factors into account can the farmer be sure that a sprinkler system will be a good investment.

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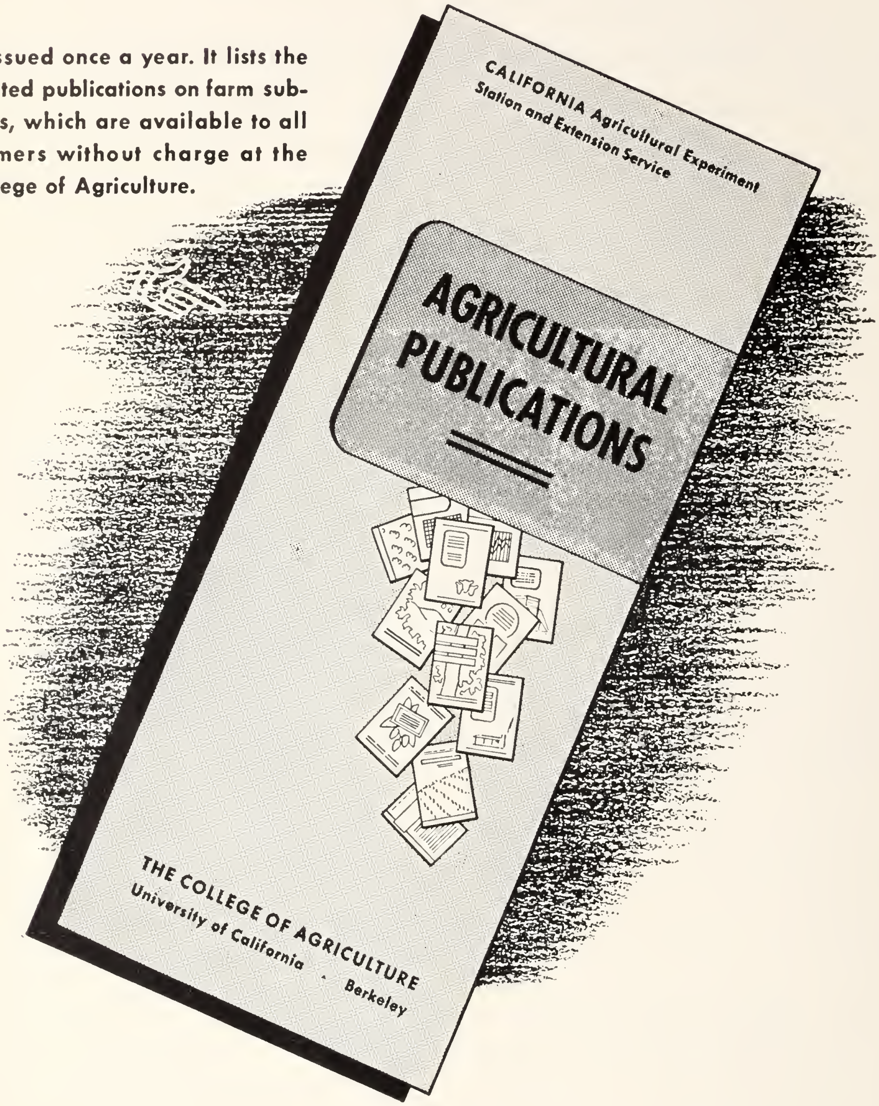

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